PGCE Science

Chemistry Practical Booklet 2025/2026

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Session 1 Observing chemical reactions

CCF Links 2 and 3

How Pupils Learn. (2)

Learn that …

- Prior knowledge plays an important role in how pupils learn; committing some key facts to their long-term memory is likely to help pupils learn more complex ideas.

Learn how to …

Avoid overloading working memory, by:
- Receiving clear, consistent and effective mentoring in how to take into account pupils' prior knowledge when planning how much new information to introduce.

Build on pupils' prior knowledge, by:
- Discussing and analysing with expert colleagues how to sequence lessons so that pupils secure foundational knowledge before encountering more complex content.

Subject and Curriculum (3)

Learn that …

- Secure subject knowledge helps teachers to teach more effectively.
- Ensuring pupils master foundational concepts and knowledge before moving on is likely to build pupils' confidence and help them succeed.

Learn how to …

Deliver a carefully sequenced and coherent curriculum, by:
- Receiving clear, consistent and effective mentoring in how to identify essential concepts, knowledge, skills and principles of the subject.
- Observing how expert colleagues ensure pupils' thinking is focused on key ideas within the subject and deconstructing this approach

And - following expert input - by taking opportunities to practise, receive feedback and improve at:
- Providing opportunity for all pupils to learn and master essential concepts, knowledge, skills and principles of the subject
- Using resources and materials aligned with the school curriculum (e.g. textbooks or shared resources) designed by expert colleagues that carefully sequence content).

Learning Objectives

Review the practical skill sets required in KS3 Chemistry.

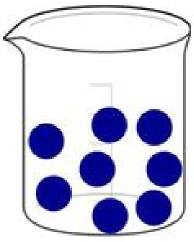
Identify how these skills translate to KS4 Chemistry.

What your students need to know:

KS3	GCSE
▪the properties of the different states of matter (solid, liquid and gas) in terms of the particle model, including gas pressure ▪changes of state in terms of the particle model ▪a simple (Dalton) atomic model ▪differences between atoms, elements and compounds ▪chemical symbols and formulae for elements and compounds ▪conservation of mass, changes of state *and chemical reactions*	▪describe the main features of the particle model in terms of states of matter and change of state ▪explain in terms of the particle model the distinction between physical changes and chemical changes ▪explain the limitations of the particle model in relation to changes of state when particles are represented by inelastic spheres (e.g. like bowling balls) that it does not take into account the forces of attraction between particles, the size of particles and the space between them ▪describe a simple model of the atom consisting of the nucleus and electrons, relative atomic mass, electronic charge and isotopes

Potential misconceptions (alternative conceptions)

- Matter is continuous, i.e. the space between gas particles is filled or non-existent,
- When a solid dissolves it no longer exists and has disappeared
- Particles expand when they are heated and contract when cooled
- Electrons orbit the nucleus like planets in the solar system
- Electrons are larger than protons and owned by their atoms



Why might children think the following: …

In each case explain how you would respond as a teacher to support their subject knowledge development.

- Sand is not a solid.
- When a solid dissolves in water it is no longer there; the substance has disappeared.
- Dissolving and melting are the same thing.
- An insulated cold substance is heated up by the insulating material, e.g. a snowman is warmed by having a coat put on.
- There needs to be a high temperature for evaporation to occur.
- The bubbles in boiling water mainly contain air (rather than gaseous water).

Exemplar: BEST resource 1 (Best evidence science teaching)

Dissolving discussion taken from:

https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching/substances-and-properties

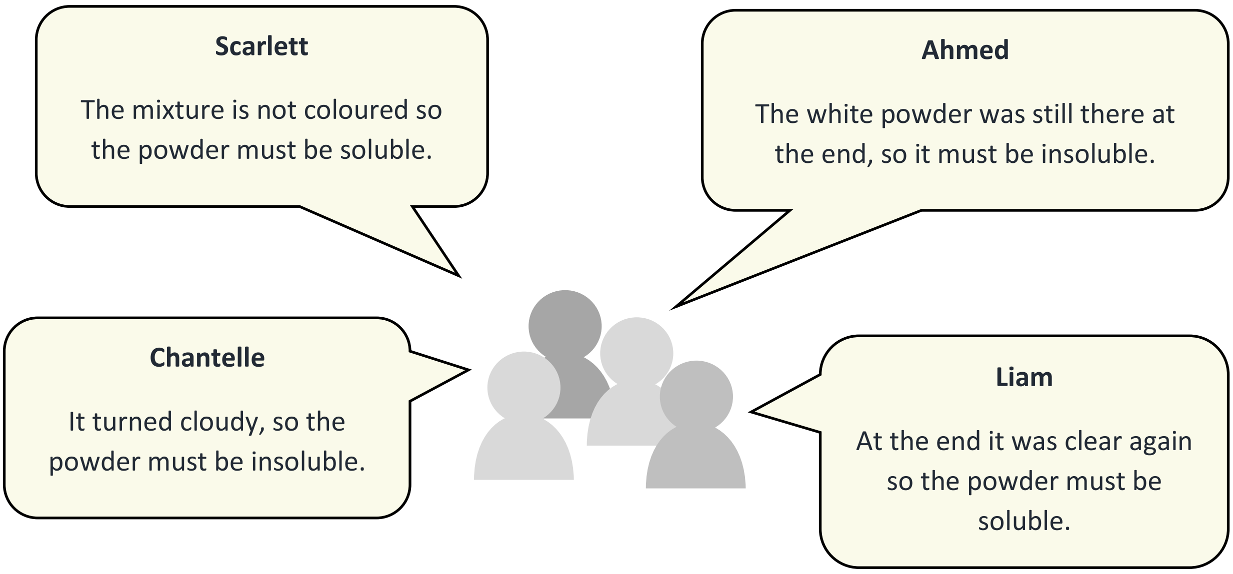
Dissolving discussion

A teaspoon of white powder was added to a beaker of water and then stirred.

At first the mixture was white and cloudy.

After a while the mixture turned clear and colourless, with a layer of white powder at the bottom.

Some children talk about what happened.



To talk about in your group -

1 Who is definitely **correct**?

2 Who is definitely **incorrect**?

3 Who is **partly** correct, and why?

4 If you think a student is partly correct, write down an improved version of their answer.

Exemplar: BEST resource 2.

https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching/particles-and-structure

Bubbles during boiling

The water inside this kettle is boiling. You can see bubbles.

What is inside the bubbles?

A Nothing

B Air particles

C Water particles

D Water particles and air

How would you explain this to your students using the particle model? What key terminology will you need to include.

Links to relevant research - Bubbles activity

Johnson, P. and Papageorgiou, G. (2010). Rethinking the Introduction of Particle Theory: A Substance-based framework. *Journal of Research in Science Teaching.* 42(2) 130-150

Links to relevant research - Dissolving activity

What does the research say?

Johnson (2012) flags up the difficulty some students have with understanding suspensions of fine powders. The powder appears to disperse through the water and some students consider this to be dissolving. This indicates that students are not using ‘clearness’ as a defining characteristic of a solution. Suspensions can be explained using the idea of particles (see key concept CPS1.2: Particles in solutions).

Johnson, P. (2012). Introducing particle theory. In Taber, K. (ed.) *ASE Science Practice: Teaching Secondary Chemistry.* New edition ed. London: Hodder Education.

Experiment 1: Microscale precipitates

1. Complete each row before moving on.

2. Put a small amount of solid into the labelled circle. Add enough water to almost fill the circle. Stir with a clean split.

3. Using a pipette put two drops of solution into the central square and mix with a clean splint.

4. Observe and record any reaction.

Wipe the sheet clean with a piece of paper towel when you have finished.

$CuCl_2$		Na_2CO_3
$CuSO_4$		Na_2CO_3
$NaCl$		KNO_3
$NaCl$		$AgNO_3$
Na_2SO_4		$Ba(NO_3)_2$
Na_2CO_3		$MgSO_4$

Experiment 2: Microscale diffusion

1. Put one drop of potassium iodide on each circle, *except the circle marked with an X.*

2. Put one drop of starch solution on .to each circle, *except the circle marked with an X.*

3. Put 2 drops of bleach on the circle marked with an X.

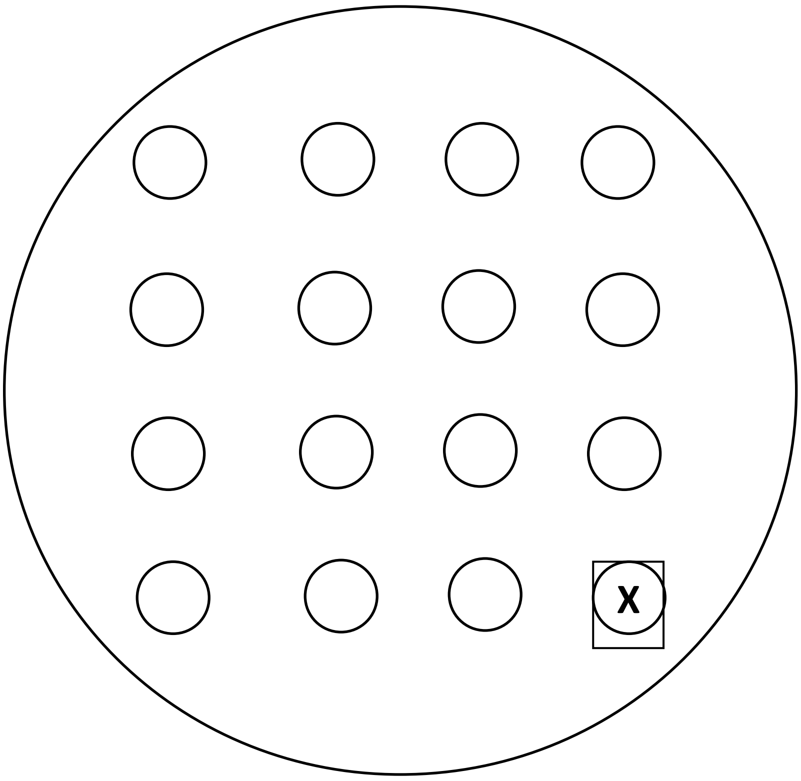
4. Put 2 drops of hydrochloric acid on to the circle marked with an X.

5. Place the petri dish lid over the circles to contain the chlorine.

6. Observe the reaction.

Further guidance is available at

https://www.youtube.com/watch?v=yFm9eafzTow



Wipe the sheet clean with a piece of paper towel when you have finished.

Experiment 3: Microscale burning magnesium

Safety precautions: Wear eye protection, tie long hair back, tuck ties in.

1. Weigh the mass of two steel bottle-tops and a 15cm length of nichrome wire.

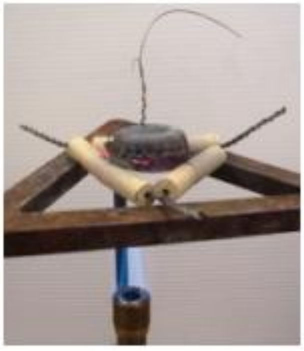
2. Record this mass.

3. Roll a 0.10g to 0.20g piece of magnesium ribbon around a pencil and place in one of the bottle-tops.

4. Reweigh the two bottle-tops, the nichrome wire and the magnesium ribbon.

5. Record this mass.

6. Set up a Bunsen burner and tripod on a heat-proof mat and place a pipe clay triangle on the tripod.



7. Put the two bottle-tops together with the magnesium ribbon in between them and wrap the wire securely around the bottle-tops to hold them together.

8. Place the bottle-tops securely on the pipe-clay triangle.

9. Heat the bottle-tops with a strong, blue Bunsen burner flame.

10. Continue heating for 10 minutes.

NOTE: It may be possible to see the magnesium ribbon glow brightly. The heat can be turned off when the magnesium is no longer glowing.

11. Turn off the Bunsen burner and allow the bottle-tops to cool (for about 5 minutes).

12. Reweigh the bottle-tops, nichrome wire and magnesium oxide.

The mass of magnesium oxide formed can be found from the weights recorded and hence the formula of magnesium oxide calculated.

H&S NOTE: Burning magnesium An intense white light is emitted (mainly visible but some in UV-A region) that can cause unpleasant dazzle and after-images that may persist for some time. The recommended method for viewing the burning metal is to wear eye protection and view through a passive welding filter lens, shade 9. considerable health and safety risks. It is no longer recommended to view burning magnesium through blue glass, smoked glass, polaroid filters, etc.

Weblinks for session 1

Microscale solubility practical https://www.scienceinschool.org/article/2022/precipitation-microscale-way/

Microscale diffusion of gases https://edu.rsc.org/experiments/diffusion-of-gases-on-a-microscale/535.article

Microscale burning magnesium. https://science.cleapss.org.uk/Resource-Info/PP063-Finding-the-Formula-of-Magnesium-Oxide.aspx

Examination questions

Q1.

This question is about metal oxides.

When sodium is heated in oxygen, sodium oxide is produced.

(a) Balance the equation for the reaction.

________ $Na + O_2 \longrightarrow 2\ Na_2O$

(1)

(b) Why is this an oxidation reaction?

____

____

(1)

(c) Sodium oxide is added to water and shaken.

Universal indicator is added.

The pH of the solution is 14

What is the colour of the universal indicator?

Tick (✔) **one** box.

Green	
Purple	
Red	
Yellow	

(1)

(d) Aluminium oxide reacts with hydrochloric acid to produce a salt.

What is the name of the salt produced?

Tick (✔) **one** box.

Aluminium chloride	
Aluminium nitrate	
Aluminium sulfate	
Aluminium sulfide	

(1)

A student investigates the solubility of four metal oxides and four non-metal oxides in water.

The student tests the pH of the solutions formed. The table shows the student's results.

Type of oxide	Oxide	Solubility in water	pH of solution
Metal oxides	Sodium oxide	Soluble	14
	Calcium oxide	Soluble	10
	Magnesium oxide	Slightly soluble	9
	Zinc oxide	Insoluble	No solution formed
Non-metal oxides	Carbon dioxide	Soluble	5
	Sulfur dioxide	Soluble	2
	Phosphorus oxide	Soluble	1
	Silicon dioxide	Insoluble	No solution formed

The student makes two conclusions.

Conclusion 1: 'All metal oxides produce alkaline solutions.'

Conclusion 2: 'All non-metal oxides produce acidic solutions.'

(e) Explain why the student's conclusions are only partly correct.

Use information from the table above.

____

____

____

____

____

(4)

(f) Give an improved conclusion for metal oxides.

Use the table above.

____

____

____

____

____

(2)

(Total 9 marks)

Mark scheme

Q1.

(a) 4 Na + O_2 ⟶ $2Na_2O$

allow multiples

1

(b) (sodium) gains oxygen

1

(c) purple

1

(d) aluminium chloride

1

(e) **Level 2 (3-4 marks):**

Relevant reasons are identified, given in detail and logically linked to form a clear account.

Level 1 (1-2 marks):

Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0

No relevant content

Indicative content

conclusion 1

- pH values above 7 are alkaline
- sodium oxide, calcium oxide and magnesium oxide do form alkaline solutions (so correct for those)
- not all metal oxides form solutions (so incorrect for zinc oxide)

conclusion 2

- pH values below 7 are acidic
- carbon dioxide, sulfur dioxide and phosphorus oxide do form acidic solutions (so correct for those)
- not all non-metal oxides form solutions (so incorrect for silicon oxide)]

4

(f) metal oxides produce alkaline solutions if they dissolve in water

*allow **1** mark for most metal oxides produce alkaline solutions*

2

[10]

Session 2: Quantitative Chemistry

CCF Links 2 and 3

How Pupils Learn (2)

Learn that …

- Working memory is where information that is being actively processed is held, but its capacity is limited and can be overloaded.

Learn how to …

Deliver a carefully sequenced and coherent curriculum, by:
- Receiving clear, consistent and effective mentoring in how to take into account pupils' prior knowledge when planning how much new information to introduce.

And - following expert input - by taking opportunities to practise, receive feedback and improve at:
Breaking complex material into smaller steps (e.g. using partially completed examples to focus pupils on the specific steps).

Build on pupils' prior knowledge, by:
- Discussing and analysing with expert colleagues how to sequence lessons so that pupils secure foundational knowledge before encountering more complex content

Subject and Curriculum (3)

Learn that …

- Secure subject knowledge helps teachers to motivate pupils and teach effectively.
- Ensuring pupils master foundational concepts and knowledge before moving on is likely to build pupils' confidence and help them succeed.
- Anticipating common misconceptions within particular subjects is also an important aspect of curricular knowledge; working closely with colleagues to develop an understanding of likely misconceptions is valuable.
- Explicitly teaching pupils the knowledge and skills they need to succeed within particular subject areas is beneficial.

Learn how to …

Deliver a carefully sequenced and coherent curriculum, by:
- Receiving clear, consistent and effective mentoring in how to identify essential concepts, knowledge, skills and principles of the subject.
- Observing how expert colleagues ensure pupils' thinking is focused on key ideas within the subject and deconstructing this approach.

And - following expert input - by taking opportunities to practise, receive feedback and improve at:
- Providing opportunity for all pupils to learn and master essential concepts, knowledge, skills and principles of the subject
- Using resources and materials aligned with the school curriculum (e.g. textbooks or shared resources designed by expert colleagues that carefully sequence content).

Learning Objectives

Review knowledge of quantitative chemistry.

Investigate some practical activities for teaching acids and alkalis and rates of reaction.

Evaluate the use of integrated instructions as a means to maximise germane load in a task.

ACIDS and TITRATIONS

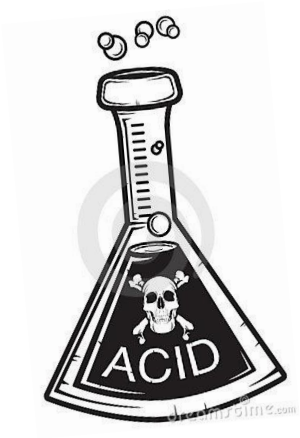
What your students need to know:

KS3	GCSE
▪defining acids and alkalis in terms of neutralisation reactions ▪the pH scale for measuring acidity/alkalinity; and indicators ▪reactions of acids with metals to produce a salt plus hydrogen ▪reactions of acids with alkalis to produce a salt plus water	▪recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions ▪describe neutralisation as acid reacting with alkali or a base to form a salt plus water ▪recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water ▪recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants ▪use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids ▪recall that relative acidity and alkalinity are measured by pH ▪describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only) ▪recall that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by a factor of one ▪calculate the chemical quantities in titrations involving concentrations in mol/dm^3 and in g/dm^3. (Higher tier only)

Introduction to acids and titrations

At KS3 students' knowledge of acids and alkalis extends to the use of acids and alkalis, neutralisation and to the pH scale and indicators. Students will be able to describe reactions of acids with alkalis, metals, carbonates.
Students develop their knowledge at GCSE to include writing chemical equations for reactions and predicting the products formed in particular reactions, as well as understanding the role of hydrogen ions in pH.
Titrations and the calculation of the concentration of an acid or an alkali features as one of the required GCSE practical tasks.

Task: Give a definition for each of the following key words:



- acid
- alkali
- salt
- neutralisation
- dilute
- concentrated
- strong
- weak
- ionisation
- pH

Write a generic word equation for each of the following reactions. Provide one example in each case.

acid + alkali → ________________ + _______________

acid + metal → _______________ + ______________

acid + carbonate → ____________ +_____________ +____________

Common misconceptions (alternative conceptions)

- acids and alkalis are all dangerous
- acids burn and eat away materials
- neutralisation is an acid breaking down
- alkalis stop the burning properties of acids
- dilution makes something weaker
- hydrogen ions in an acid are still part of the molecule, not free in the solution
- alkalis are less corrosive than acids.
- strength and concentration are the same
  https://www.stem.org.uk/elibrary/list/16137/strong-and-weak-acids-and-bases

The idea of the formation and naming of a salt in acid reactions causes difficulty for some students in KS3.

Exemplar BEST resource 1 – Which pH?

https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching/substances-and-properties

A student finds the pH of 6 different solutions. The results are shown below.

Solution	pH
A	4
B	6
C	1
D	12
E	10
F	8

1 Write down the letter of the solution that matches each statement below.

a A solution that is more acidic than B.

b A solution that is more alkaline than E.

c The least acidic solution.

d The least alkaline solution.

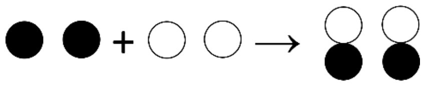
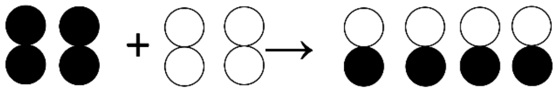
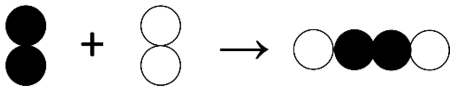
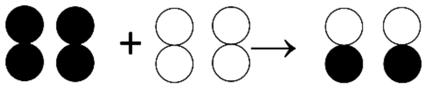
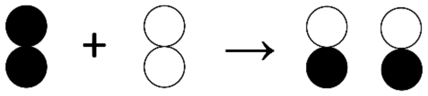
Exemplar BEST resource 2: Equation diagrams

https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching/chemical-reactions

Which particle diagrams could be represented by the balanced chemical equation below?

$$X_2 + Y_2 \rightarrow 2XY$$

X = ●
Y = ○

*For each statement, tick (✓) **one** column to show what you think.*		I am **sure** this is right	I think this is right	I think this is wrong	I am **sure** this is wrong
A					
B					
C					
D					
E					

Teaching acids and titrations

Students, at KS3, enjoy the many colourful practical activities associated with this topic! In addition, there are opportunities to develop investigative skills important to Working Scientifically.

When trying out activities, consider how you will introduce the experiments to your students, what you will say when you carry out any demonstrations and how much information you will give to your students if they do an investigation.

Experiment 1: Titration
AQA GCSE Chemistry required practical activity (from AQA booklet)

Neutralisation: Investigation to find the concentration of a dilute sulfuric acid solution using a sodium hydroxide solution of known concentration.

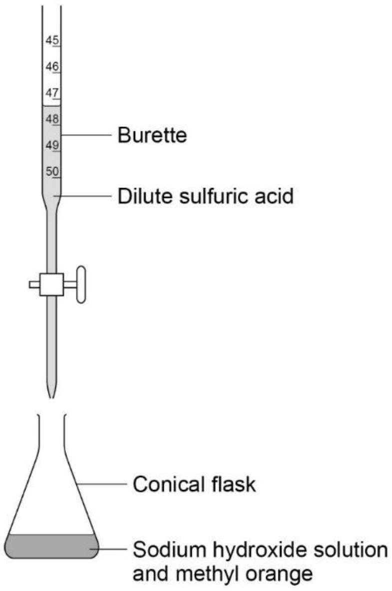
AT 1- Use of appropriate apparatus to make and record a range of measurements accurately, including volume of liquids. AT 8 - The determination of concentrations of strong acids and strong alkalis.

You will find the volume of dilute sulfuric acid needed to neutralise 25 cm^3 of 0.5 mol/dm^3 sodium hydroxide solution. An indicator is used to observe the colour change in an acid-base indicator.

The sulfuric acid has an unknown concentration. You also calculate the concentration of the sulfuric acid used in mol/dm^3 and g/dm^3.

Method

You are provided with the following:



- ✓ 25 cm^3 volumetric pipette and pipette filler
- ✓ burette
- ✓ small funnel
- ✓ clamp stand
- ✓ 250 cm^3 conical flask
- ✓ white tile
- ✓ dilute sulfuric acid of unknown concentration
- ✓ 0.1 mol/dm^3 sodium hydroxide solution
- ✓ methyl orange indicator.

1. Use the pipette and pipette filler to put exactly 25 cm^3 sodium hydroxide solution into the conical flask. Stand the flask on a white tile.

2. Clamp the burette vertically in the clamp stand about halfway up its length. There should be just enough room underneath for the conical flask and tile.

3. Close the burette tap.

4. Use the small funnel to carefully fill the burette with dilute sulfuric acid to the 0 cm^3 line. You should do this at a low level so that you are not pouring

acid from above head height. For example, put the clamp stand temporarily on a lab stool or the floor.

5. Put 5–10 drops of methyl orange indicator into the conical flask. Swirl to mix and place under the burette with the tile.

6. Carefully open the tap so that sulfuric acid flows into the flask at a drop by drop rate. Constantly swirl the flask when adding the acid. Look for a colour change from yellow to red in the indicator.

7. There will be signs that the colour change is close to being permanent. When this happens use the tap to slow the drops down. You need be able to shut the tap immediately after a single drop of acid causes the colour to become permanently red.

8. Read the burette scale carefully and record the volume of acid you added. You can use a table such as the one below.

Volume of dilute sulfuric acid required needed to neutralise 25cm^3 sodium hydroxide solution (cm^3)			
Trial 1	**Trial 2**	**Trial 3**	**Mean**

9. Repeat steps 1–7 twice more and record the results in the table

10. Calculate the mean value for the volume of acid needed to neutralise 25 cm^3 of the sodium hydroxide solution. Record this value in the final space in the table. Use your mean result to calculate the concentration of the acid in mol/dm^3 and g/dm^3 using the following calculation steps.

Calculation

Step 1

Concentration (mol/dm^3) = number of moles ÷ volume of solution (dm^3)

Moles of sodium hydroxide in 25 cm^3 = concentration × volume = 0.1 mol/dm^3 × (25 ÷ 1000) dm^3

= ______________ moles

Step 2

Equation: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

This shows that **two** moles of sodium hydroxide neutralise **one** mole of sulfuric acid.

So moles of sulfuric acid used = (answer from step **1**) ÷ 2

= ______________ moles

Step 3

Concentration of sulfuric acid (mol/dm^3) = moles ÷ mean volume of acid

= (answer from step **2**) ÷ (mean volume from table ÷ 1000)

= ______________ mol/dm^3

Number of moles = mass of substance (g) ÷ M_r of substance

A_r (H) = 1; A_r (O) = 16; A_r (S) = 32

M_r (H_2SO_4) = ______________

Concentration of sulfuric acid (g/dm^3) = (answer from step **3**) × M_r (H_2SO_4)

= ______________ g/dm^3

Questions to consider

- What safety precautions should you take when carrying out this experiment and why?
- Why is a burette used to measure the volume of one of the solutions instead of a measuring cylinder?
- Why is it necessary to rinse the burette and pipette with the solutions they will contain before filling them?
- Why is it necessary to use an indicator in the titration?
- What are the colours of methyl orange in acid, neutral and alkaline solutions?
- What are the colours of phenolphthalein in acid, neutral and alkaline solutions?
- Why is universal indicator not suitable to use in a titration?
- Why is a white tile used?
- Why is it important to swirl the conical flask during the titration?
- What is meant by the end point?
- Why do you repeat the titration?
- What are concordant results?
- Which results are included in the calculation when you determine the mean or average titre?

Integrated instructions

Conducting experiments can be an inherently challenging task with numerous competing sources of information such as substantive knowledge, refinement of pre developed skills, development of new skills, and working scientifically skills all competing within working memory. This can be exacerbated by the fact that without practice and recall new information is quickly forgotten and not coded into schema in the long term memory.

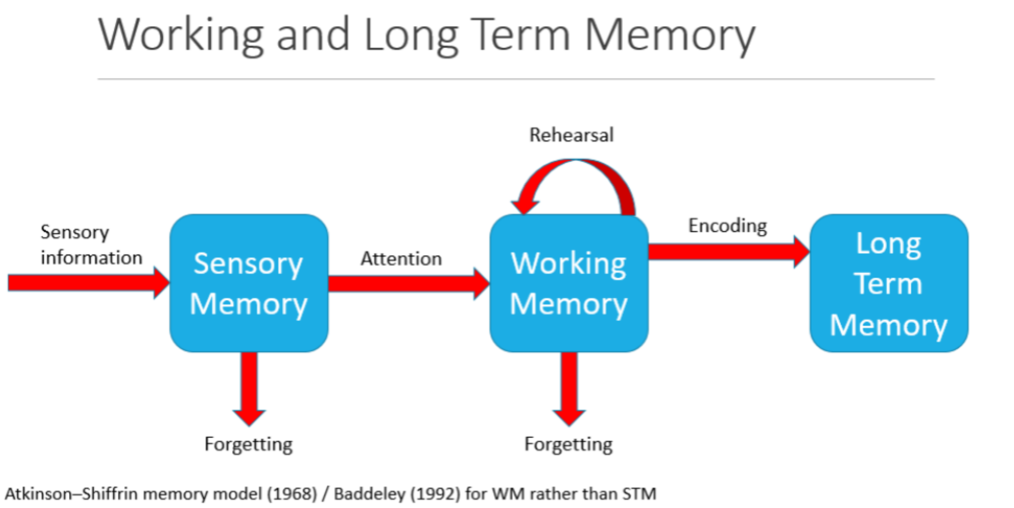
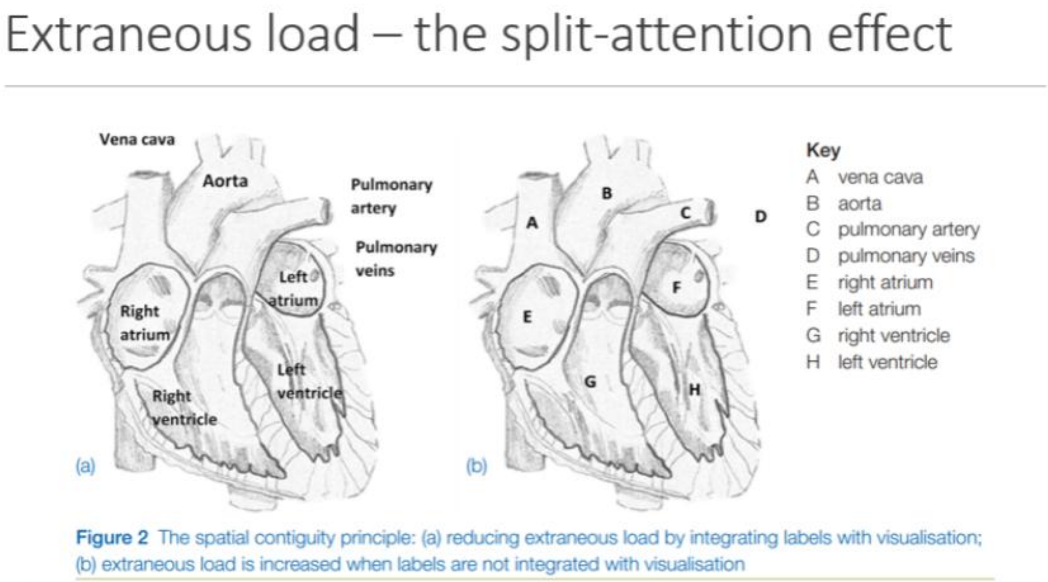


Figure taken from presentation from Dr David Paterson PGS6062 2020.

Encoding can help develop schema which can then be retrieved to the working memory when needed. Take the example of heating 50cm3 water with a Bunsen burner. We all intrinsically recognise that we need a source of heat, gauze, tripod beaker and if we want a particular temperature a thermometer. We do not need a list of separate instructions to set up this equipment. We recognise that we have set up this equipment hundreds of times before so it has been coded into our long-term memory. Each task has an intrinsic load associated with the task. If we can manage the intrinsic load we can maximise the germane load, and increase the likelihood of information being transferred into long term memory. Good sequencing of instructions can manage intrinsic load. Equally extraneous load should be reduced. The split attention effect shows that if instructions are integrated the extraneous load of the task can be reduced.



Torrance Jenkins, *Using educational neuroscience and*
y to teach science Part 1. **SSR December 2017**

Research has shown that if you combine labelling within images rather than creating separate keys extraneous load can be reduced. For more on integrated instructions click [here.]

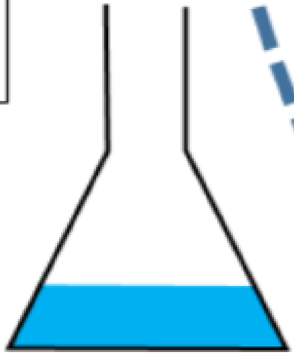
Experiment 1:   Titration – INTEGRATED INSTRUCTIONS

Risk assessments:
If you are going to carry out practicals following these instructions, you must carry out appropriate risk assessments first. I suggest the use of CLEAPSS resources for this.

NOTE: These documents are shared for information and training purposes.

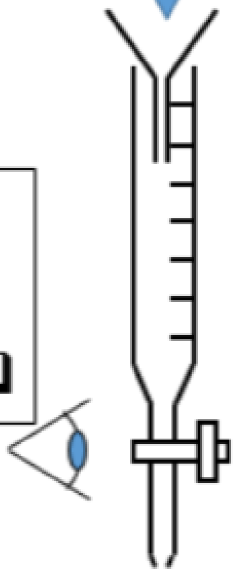
❶ 25.0 cm^3 NaOH (pipette) ❑ ❑ ❑

❷ 5-10 drops of indicator ❑ ❑ ❑



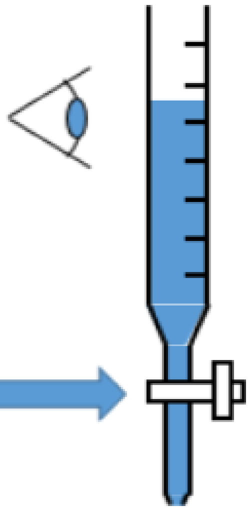
❹ Fill to 0.0 cm^3 with H_2SO_4 ❑ ❑ ❑

❸ Tap is closed ❑ ❑ ❑

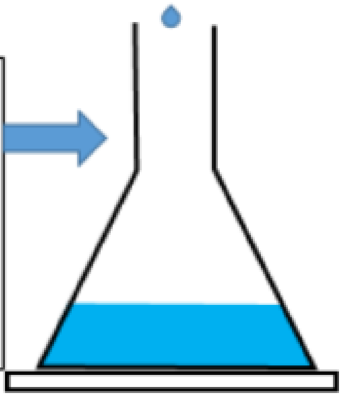


❼ Measure and record volume ❑ ❑ ❑

❺ Add H_2SO_4 and .... ❑ ❑ ❑



❻ ... swirl until colour change ❑ ❑ ❑



GCSE Chemistry: Neutralisation
Designed in line with practicals in AQA GCSE Chemistry / Combined Science Handbooks
http://www.aqa.org.uk/resources/science/gcse/teach/practicals

Experiment 2: Microscale titration

Apparatus:

- hydrochloric acid of unknown concentration
- 0.1 $moldm^{-3}$ sodium hydroxide solution
- phenolphthalein indicator solution in dropping bottle or with extra dropping pipettes
- clamp stand, boss and clamp
- white tile
- extended fine tip Pasteur pipettes (delivering 50 drops / cm^3)

Method:

1. Place 1 drop of phenolphthalein indicator into a clean vial. Weigh vial and contents and record the mass (M1).
2. Add approximately 1cm^3 of Hydrochloric acid of unknown concentration into the vial. Weigh the vial and contents and record the mass (M2).
3. Squeeze the bulb of the micro Pasteur pipette as tightly as possible and suck up the sodium hydroxide solution.
4. Clamp the pipette as shown.
5. Slowly turn the screw on the clamp stand to add the sodium hydroxide solution to the vial containing the indicator solution and hydrochloric acid. Gently swirl the vial to mix the contents as the drops of sodium hydroxide solution are added.
6. When a permanent colour change has been achieved, weigh the vial and its contents and record the mass (M3).
7. Use your results to determine the concentration of the acid.

<u>Assume</u> all solutions have a density of 1g/cm^3 so 1g is equivalent to 1cm^3.

<u>Use the formulae</u>

Moles = volume (dm^3) x concentration (mol dm^{-3})

Mass (g) = moles x molar mass

EXAMINATION QUESTION

8. A titration is to be carried out to find the concentration of a solution of sodium hydroxide.

The sodium hydroxide solution is titrated with dilute sulfuric acid.

The available apparatus includes a burette, a pipette, a funnel, a conical flask and an indicator.

(a) State one safety precaution that must be taken when using sodium hydroxide solution and dilute sulfuric acid. (1)

....

(b) The sodium hydroxide solution is made by dissolving 4.3 g of sodium hydroxide in water and making the solution up to 250 cm^3 with water.

Calculate the concentration of the solution in g dm^{-3}. (2)

concentration = ... g dm−3

(c) Write the balanced equation for the reaction of dilute sulfuric acid, H2SO4, with sodium hydroxide. (2)

....

(d) The results of titrations to determine how much of an acid is required to neutralise a given volume of an alkaline solution are shown .below.

	titration 1	titration 2	titration 3	titration 4
final burette reading (cm^3)	27	27.40	29.20	29.30
initial burette reading (cm^3)	0	2.10	4.00	3.50
volume of acid used (cm^3)	27	25.30	25.20	25.80

Two of the titrations should **not** be used to calculate the mean volume of acid required. Identify each titration and give a reason why it should not be used in the calculation of the mean. (2)

....

....

Question number	Answer	Mark
8(a)	any **one** precaution from: • wear gloves to prevent contact with skin/safety (1) • spectacles to prevent contact with eyes (1)	**(1)**

Question number	Answer	Additional guidance	Mark
8(b)	1000 cm^3 contain $\frac{4.3 \times 1000}{250}$ (1) 1 dm^3 contains 17.1 ($g\,dm^{-3}$) (1)	Award full marks for correct numerical answer without working.	**(2)**

Question number	Answer	Additional guidance	Mark
8(c)	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ • correct formulae (1) • balancing (1)	Do not award 2 if incorrect balancing added.	**(2)**

Question number	Answer	Mark
8(d)	• {titration 1/27 cm^3} should not be used because burette readings {not precise/not accurate/not read to 2 d.p.} (1) • {titration 4/25.80 cm^3} should not be used because volume of used (25.80 cm^3) not concordant with other two (1)	**(2)**

Improve your subject knowledge

RSC

http://www.rsc.org/learn-chemistry/resource/res00002077/titration-screen-experiment

https://edu.rsc.org/cpd/moles-and-titrations/2000006.article

https://edu.rsc.org/practical/simple-titration-practical-videos-14-16-students/4011981.article

Teachers TV lesson idea – *this is great!*

https://www.stem.org.uk/elibrary/resource/30894

GCSE Chemistry with mini quizzes

http://www.gcsescience.com/aa29.htm

Doc Brown

http://www.docbrown.info/page03/AcidsBasesSalts10.htm

RATES of REACTION

Introduction to rates

The rate of a chemical reaction can be found by measuring the quantity of a reactant used up or the amount of a product formed with time.

rate = quantity of reactant used / time taken
or
rate = quantity of product formed / time taken

The units of the rate of a reaction are g/s or cm^3/s or mol/dm^3.

It is important in this topic that students are able to draw and interpret graphs showing the quantity of reactant used up and product formed against time.

Students should also be able to draw tangents to the curve on the graphs and use the slope of the tangent to as a measure of rate of reaction.

There are several key factors that affect the rate of a chemical reaction; concentration, temperature, surface area and pressure in a gaseous reaction. Using the collision theory, students should be able to explain the effects of changes in these factors on the rate of a reaction. Catalysts also increase the rate of a chemical reaction.

For a chemical reaction to occur the reacting particles must collide with sufficient kinetic energy to break chemical bonds so that a reaction can occur. This minimum amount of energy is called the activation energy.

What your students need to know

KS3	GCSE
There is no KS3 content for this topic.	▪ describe the effect of changes in temperature, concentration, pressure, and surface area on rate of reaction ▪ explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles ▪ explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio ▪ suggest practical methods for determining the rate of a given reaction ▪ interpret rate of reaction graphs

Common misconceptions (alternate conceptions)

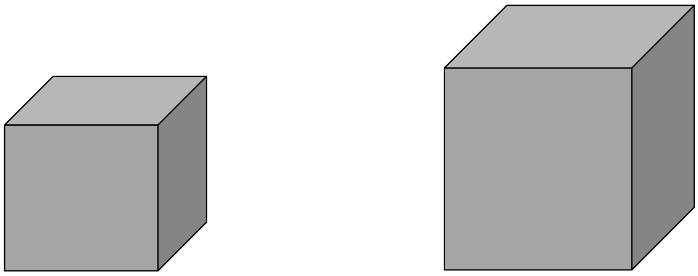
- misinterpretation of rate of reaction graphs
- catalysts get used up or run out.

Exemplar BEST resource 1 – Reacting gases

. https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching/chemical-reactions

1 Two containers contain the same number of molecules of reacting gases.

Container A has a smaller volume than container B.



container A container B

a. In which container is the rate of reaction faster?

Put a tick (✓) in the box next to the best answer.

A	A	☐
B	B	☐
C	Neither (rate of reaction is the same)	☐

b. Explain your answer to part a.

Put a tick (✓) in the box next to the statement that best explains your answer to part a.

A	There are the same number of reactant molecules in each container.	☐
B	The molecules are moving faster.	☐
C	The pressure is greater.	☐
D	The reactant molecules collide more frequently.	☐
E	There are more collisions between reactant molecules.	☐

Experiment 3: Rates of reaction (AQA required practical activity)

Rates of reaction: Investigation into how the concentration of a solution affects the rate of a chemical reaction.

There are two parts to this practical which investigate how the rate of reaction can be measured, observing a colour change (activity 1) and measuring the volume of a gas produced (activity 2).

Risk assessment:

Goggles should be worn at all times

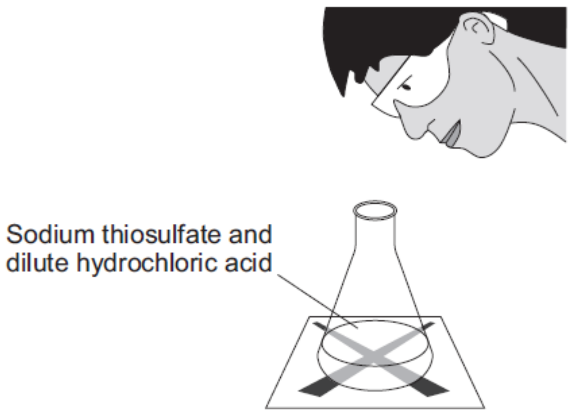
Sulfur dioxide is released during the reaction which can exacerbate breathing difficulties in people with pre-existing conditions such as asthma.

Activity 1: Observing colour change

Method

You are provided with the following:

- ✓ 40 g/dm^3 sodium thiosulfate solution
- ✓ 2.0 M dilute hydrochloric acid
- ✓ 10 cm^3 measuring cylinder
- ✓ 100 cm^3 measuring cylinder
- ✓ 100 cm^3 conical flask
- ✓ printed black paper cross
- ✓ stop clock.



1. Use a measuring cylinder to put 10 cm^3 sodium thiosulfate solution into the conical flask. Use the measuring cylinder to then add 40 cm^3 water. This dilutes the sodium thiosulfate solution to a concentration of 8 g/dm^3. Put the conical flask on the black cross.
2. Put 10 cm^3 of dilute hydrochloric acid into the 10 cm^3 measuring cylinder.
3. Put this acid into the flask. At the same time swirl the flask gently and start the stop clock.
4. Look down through the top of the flask. Stop the clock when you can no longer see the cross. **Take care to avoid breathing in any sulfur dioxide fumes.**
5. Write the time it takes for the cross to disappear in the first blank column of the table such as the one below. Record the time in seconds.

Concentration of sodium thiosulfate in g/dm^3	Time taken for cross to disappear in seconds			
	First trial	**Second trial**	**Third trial**	**Mean**
8				
16				
24				
32				
40				

6. Repeat steps **1–5** four times, **but in step 1 use:**
   - 20 cm^3 sodium thiosulfate + 30 cm^3 water (concentration 16 g/dm^3)
   - 30 cm^3 sodium thiosulfate + 20 cm^3 water (concentration 24 g/dm^3)
   - 40 cm^3 sodium thiosulfate + 10 cm^3 water (concentration 32 g/dm^3)
   - 50 cm^3 sodium thiosulfate + no water (concentration 40 g/dm^3)

7. Then repeat the whole investigation (steps 1–5) twice more.

   Record the results in the second and third blank columns of the table.

8. Calculate the **mean** time for each of the sodium thiosulfate concentrations. Leave out anomalous values from your calculations.

   Record the means in the fourth blank column.

9. Plot a graph with:
   - 'mean time taken for cross to disappear in seconds' on the y-axis
   - 'sodium thiosulfate concentration in g/dm^3' on the x-axis

   Draw a smooth curved line of best fit.

   What can you say about the effect of the independent variable (concentration) on the dependent variable (time taken for the cross to disappear)? What were your control variables?

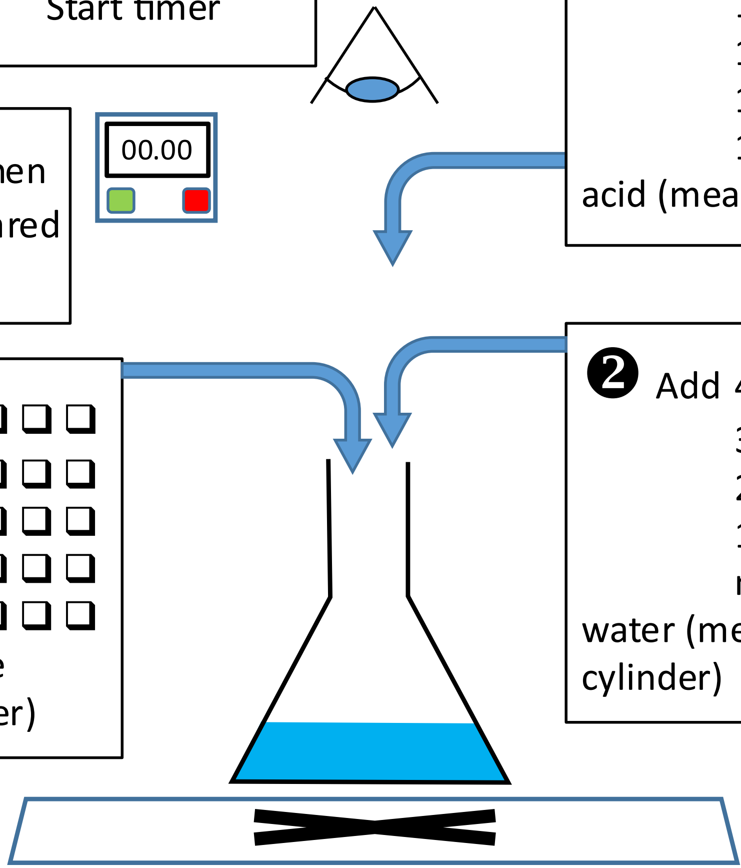
❶ Add $10cm^3$ ☐ ☐ ☐
$20cm^3$ ☐ ☐ ☐
$30cm^3$ ☐ ☐ ☐
$40cm^3$ ☐ ☐ ☐
$50cm^3$ ☐ ☐ ☐
sodium thiosulfate (measuring cylinder)

❷ Add $40cm^3$ ☐ ☐ ☐
$30cm^3$ ☐ ☐ ☐
$20cm^3$ ☐ ☐ ☐
$10cm^3$ ☐ ☐ ☐
no cm^3 ☐ ☐ ☐
water (measuring cylinder)

❸ Add $10cm^3$ ☐ ☐ ☐
$10cm^3$ ☐ ☐ ☐
$10cm^3$ ☐ ☐ ☐
$10cm^3$ ☐ ☐ ☐
$10cm^3$ ☐ ☐ ☐
acid (measuring cylinder)

❹ Swirl flask
Place on cross
Start timer

❺ Stop timer when cross has disappeared – record time



GCSE Chemistry: Rates of reaction 1
Designed in line with practicals in AQA GCSE Chemistry / Combined Science Handbooks
http://www.aqa.org.uk/resources/science/gcse/teach/practicals

NOTE: There is also a microscale version of this rates of reaction practical activity. This version offers the advantages of being small scale and thus reduces the amount of chemicals needed. In addition, it is carried out in a closed container avoiding any health and safety issue associated with the generation of sulfur dioxide, a respiratory irritant and can cause breathing difficulties.

https://science.cleapss.org.uk/Resource/PP041-The-thiosulfate-acid-reaction-rate-and-concentration.pdf

EXAMINATION QUESTION

5 A student used the equipment in Figure 6 to investigate the rate of reaction between zinc and excess dilute hydrochloric acid.

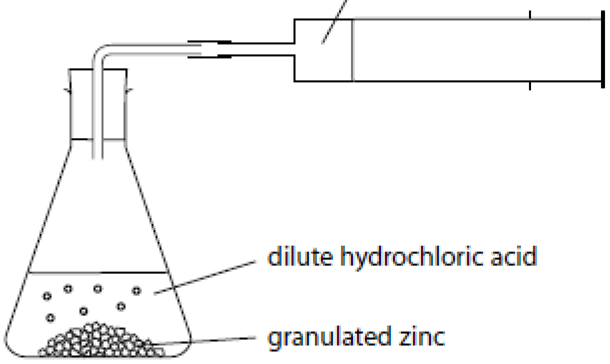


Figure 6

The student uses the following method:

- place a known mass of granulated zinc into the conical flask
- pour 25 cm^3 of dilute hydrochloric acid (an excess) into the conical flask and fit the bung quickly into the neck of the flask
- measure the volume of gas produced every 20 seconds until after the reaction finishes.

Figure 7 shows the results.

time / s	**volume of hydrogen / cm^3**
0	0
20	42
40	66
60	75
80	80
100	82
120	82
140	82

Figure 7

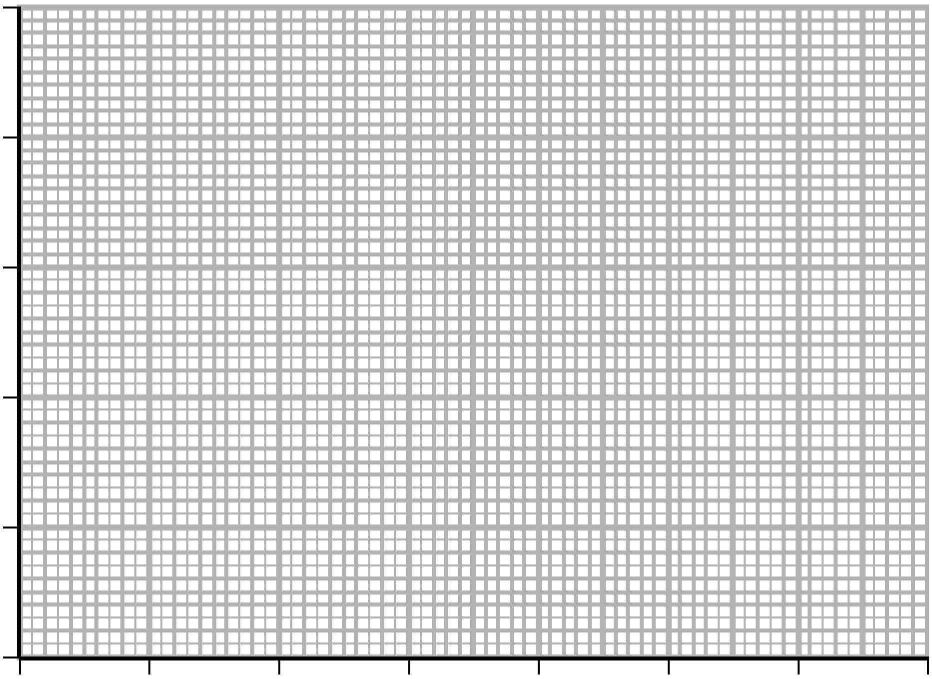
(a) Give the name of a piece of equipment that can be used to measure 25 cm^3 of dilute hydrochloric acid accurately.

(1)

....

(b) Draw a graph of the volume of hydrogen gas produced against time using the grid.

(3)



(c) The average rate of reaction in the first 20 seconds in cm^3 of hydrogen produced per second is

(1)

- ☐ **A** 2.1
- ☐ **B** 8.4
- ☐ **C** 21
- ☐ **D** 84

(d) The student repeated the experiment keeping all conditions the same but using the same mass of powdered zinc instead of granulated zinc.

On the grid above sketch the graph you would expect when the experiment is repeated using powdered zinc.
Label your line **A**.

(2)

(e) Sodium thiosulfate solution, $Na_2S_2O_3$, reacts with dilute hydrochloric acid as shown in the equation.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(s) + H_2O(l) + S(s) + SO_2(g)$$

The rate of this reaction can be investigated by mixing the reactants and finding the time taken for a precipitate of sulfur to become visible.

A student wants to investigate the effect of changing the temperature on the rate of this reaction.

Devise a method the student could use to find out how the time taken for the precipitate of sulfur to become visible changes with temperature.

(3)

(Total for Question 5 = 10 marks)

Question number	Answer	Mark
5(a)	Measuring cylinder/burette/pipette	(1)

Question number	Answer	Additional guidance	Mark
5(b)	• axes with linear scale that use more than half of each edge of the grid and labelled with units from the table (1). • all points correctly plotted to ± half a square (1). • single straight line passing through all points and the origin (1).	7 points plotted correctly (i.e. one error) (1) allow ecf from plotting error.	(3)

Question number	Answer	Mark
5(c)	A	(1)

Question number	Answer	Mark
5(d)	Line A on graph: • steeper curve/curve drawn to left of original (1) • levelling off at 82 cm^3 (1)	(2)

Question number	Answer	Mark
5(e)	An answer that combines the following points to provide a method: • suitable method of warming the solutions, e.g. water bath, Bunsen burner with tripod and gauze and measure the temperature of each solution using a thermometer (1) • use the same volumes of the solutions in each experiment (1) • measure the time for the precipitate to form (and obscure a cross placed under the reaction vessel) using a stop watch/clock (1)	(3)

Improving your subject knowledge:

BBC Bitesize

http://www.bbc.co.uk/education/guides/zwdp34j/revision

Doc Brown

http://www.docbrown.info/page03/3_31rates.htm

Student Room

http://www.thestudentroom.co.uk/wiki/Revision:Collision_Theory

Chemguide (A-level):

http://www.chemguide.co.uk/physical/basicrates/introduction.html

You might be interested the RSC rhubarb experiment!

http://www.rsc.org/learn-chemistry/resource/res00000745/rates-and-rhubarb

http://www.rsc.org/learn-chemistry/resource/res00000413/the-effect-of-concentration-and-temperature-on-reaction-rate

Session 3 Qualitative tests

CCF Links 2

How Pupils Learn (2)

Learn that …

- Prior knowledge plays an important role in how pupils learn; committing some key facts to their long-term memory is likely to help pupils learn more complex ideas.
- An important factor in learning is memory, which can be thought of as comprising two elements: working memory and long-term memory.

Learn how to …

Avoid overloading working memory, by:

- Receiving clear, consistent and effective mentoring in how to take into account pupils' prior knowledge when planning how much new information to introduce.
- Discussing and analysing with expert colleagues how to reduce distractions that take attention away from what is being taught (e.g. keeping the complexity of a task to a minimum, so that attention is focused on the content).

LO To describe how to conduct a range of qualitative tests.

Introduction to chemical reactions and qualitative analysis

The behaviour of and trends and patterns in the properties of elements is explained by reference to the Periodic Table.

The position of an element in the Periodic Table is determined by the atomic structure of an element.

Chemical reactions occur when two or more atoms bond together or when between atoms are broken.

The shapes of molecules and the arrangement of atoms in giant structures is important in terms of their chemical behaviour.

Chemical reactions take place in only three different ways:

- electron transfer
- electron sharing
- proton transfer

Give a definition for each of the following key words:

- decomposition
- neutralisation
- addition
- redox
- combustion
- displacement
- precipitation
- electrolysis
- electrode
- cathode
- anode
- cation
- anion

What your students need to know

KS3	GCSE
▪ chemical reactions as the rearrangement of atoms ▪ representing chemical reactions using formulae and using equations ▪ combustion, thermal decomposition, oxidation and displacement reactions	▪ describe tests to identify selected gases including oxygen, hydrogen, carbon dioxide and chlorine ▪ describe tests to identify aqueous cations and aqueous anions including calcium, copper, iron (II), iron (III) and zinc using sodium hydroxide and carbonates and sulfates using aqueous barium chloride followed by hydrochloric acid; chloride, bromide and iodide using silver nitrate ▪ describe how to perform a flame test and interpret flame tests to identify the ions of lithium, sodium, potassium, calcium and copper ▪ recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes ▪ predict the products of electrolysis of binary ionic compounds in the molten state ▪ describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present ▪ describe electrolysis in terms of the ions present and reactions at the electrodes

Common misconceptions (alternative conceptions)

- Confusion between anode and cathode and anion and cation.
- Ionic solutions conduct because of movement of electrons.
- Ionic solids do not conduct because electrons cannot move.

Experiment 1: Microscale Qualitative Analysis - Anions / Negative ions

- Follow the procedure outlined in each section to test for carbonates, halides and sulphates.
- Record your observations.
- Describe the test for each negative ion and try to explain the chemistry.

Testing for carbonate ions, CO_3^{2-}

- Add 2 drops of the appropriate anion solution to each square, as indicated.
- Add 1 drop of Universal Indicator and stir carefully.
- Add 1 drop of hydrochloric acid to any solution that is alkaline (turned blue).

Chloride, Cl^-	Bromide, Br^-	Iodide, I^-	Carbonate, CO_3^{2-}	Sulphate, SO_4^{2-}

Testing for halide ions, Cl^-, Br^-, I^-

- Add 2 drops of the appropriate anion solution to each square, as indicated.
- Add 2 drops of nitric acid followed by 1 drop of silver nitrate solution.
- Add 2 drops of ammonia solution to square with a precipitate and stir carefully.

Chloride, Cl^-	Bromide, Br^-	Iodide, I^-	Carbonate, CO_3^{2-}	Sulphate, SO_4^{2-}

Testing for sulphate ions, SO_4^{2-}

- Add 1 drop of barium chloride solution.
- Add 1 drop of hydrochloric acid to any square with a precipitate.

Chloride, Cl^-	Bromide, Br^-	Iodide, I^-	Carbonate, CO_3^{2-}	Sulphate, SO_4^{2-}

Wipe the sheet clean with a piece of paper towel when you have finished.

https://science.cleapss.org.uk/Resource/PP109-Anion-analysis-Microscale.pdf

Experiment 2: Qualitative Analysis - Cations / Positive ions

Flame tests can be used to identify some positive ions such as sodium, lithium, potassium and copper.

Other positive ions can be identified by their reaction with sodium hydroxide solution and ammonia solution.

Use the grid to test the reaction of some positive ions with

- sodium hydroxide solution
- excess sodium hydroxide solution
- ammonia solution
- excess ammonia solution

Ions tested / Reagent added	**2 drops Cu2+ ↓**	**2 drops Fe2+ ↓**	**2 drops Fe3+ ↓**	**2 drops Ca2+ ↓**	**2 drops Al3+ ↓**
1 drop H_2O →					
1 drop NaOH →					
5 drops NaOH →					
1 drop NH_3 →					
5 drops NH_3 →					

Wipe the sheet clean with a piece of paper towel when you have finished.

https://science.cleapss.org.uk/Resource/PP098-Testing-for-positive-ions-reactions-with-hydroxides-and-ammonia.pdf

EXPERIMENT 3: ELECTROLYSIS - Investigate what happens when two different aqueous solutions are electrolysed using inert electrodes

AT 3 - Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions. AT 7 - Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds. AT 8 - Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests for hydrogen, oxygen and chlorine.

In this practical you will:

- Use a low voltage power supply and carbon rod electrodes to pass a current through two different salt solutions
- Identify the element formed at the positive and negative electrodes for each solution
- Add extra detail to the basic electrochemical diagram provided

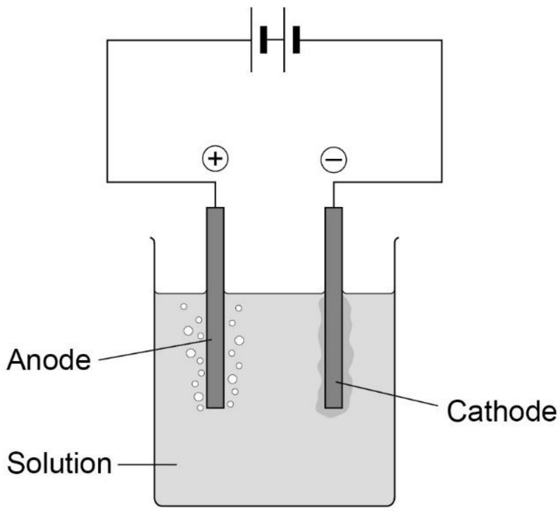
Apparatus:

- 50 cm3 copper(ll) sulphate solution
- sodium chloride solution
- 100 cm^3 beaker
- Petri dish lid
- two carbon rod electrodes
- low voltage power supply / two crocodile / 4 mm plug leads
- blue litmus paper
- tweezers

Method

1. Pour approximately 50 cm^3 copper (II) sulphate solution into the beaker.

2. Add the lid and insert carbon rods through the holes. **The rods must not touch each other**.



3. Attach crocodile leads to the rods. Connect the rods to the dc (red and black) terminals of a low voltage power supply.

4. Select 4 V on the power supply and switch on.

5. Look at both electrodes and record your initial observations in the table below.

6. Use tweezers to hold a piece of blue litmus paper in the solution next to the positive electrode (the one connected to the red terminal). You will need to lift the lid temporarily to do this.

Solution	**Positive electrode (anode)**		**Negative electrode (cathode)**	
	Observations	**Element formed and state**	**Observations**	**Element formed and state**
Copper (II) sulphate				
Sodium chloride				

7. **After no more than four minutes**, switch off the power supply.

   Examine both electrodes and record your observations. Record your results in the table.

   Explain your results and write half-equations.

NOTE: Gas produced at the positive electrode that does *not* bleach litmus paper is oxygen.

Gas produced at the negative electrode is hydrogen.

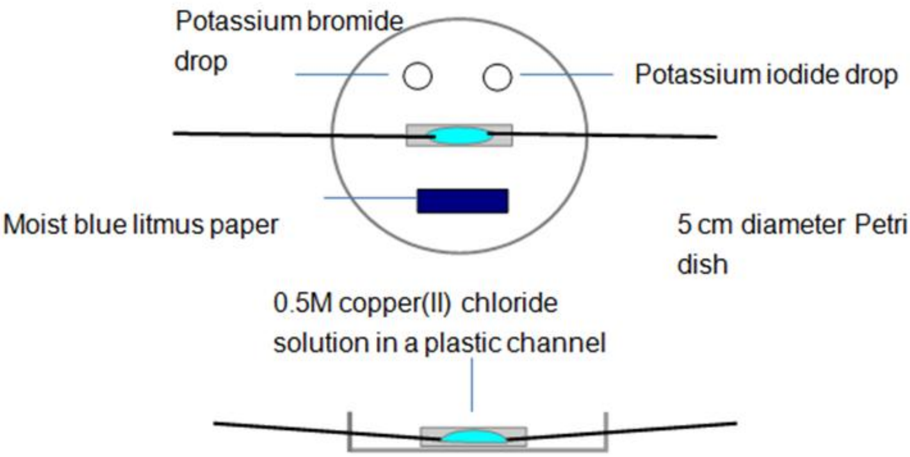
EXPERIMENT 4: MICROSCALE ELECTROLYSIS

There are a number of advantages to the use of microscale techniques for electrolysis. What are they?

Electrolysis of copper chloride

Apparatus / Chemicals:

- ✓ petri dish fitted with 2 carbon fibre electrodes and a plastic channel
- ✓ power pack, leads and crocodile clips
- ✓ litmus paper
- ✓ copper(II) chloride solution, 0.5 mol dm^{-3}
- ✓ potassium bromide solution, 2 mol dm^{-3}
- ✓ potassium iodide solution, 1 mol dm^{-3}



Procedure:

▪Set the equipment up as in the diagram adding the solutions in the following order to prevent reactions –

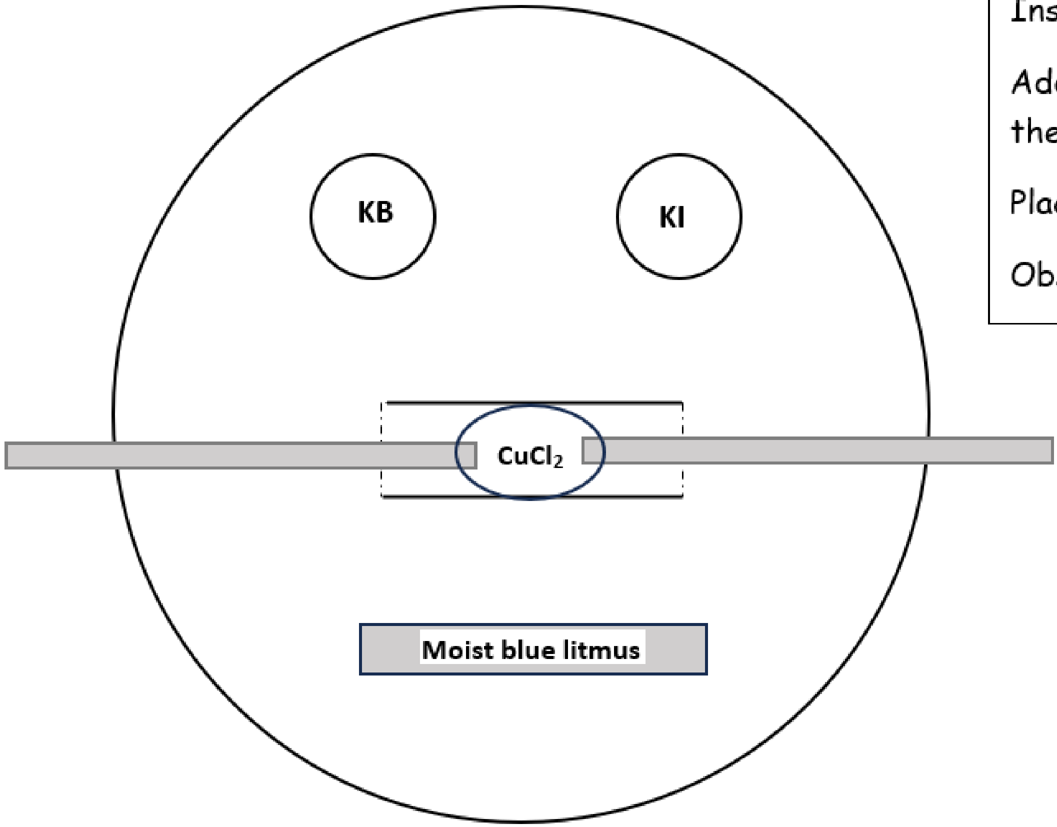
*1 -2 drops of potassium bromide
*1 – 2 drops of potassium iodide
*damp litmus paper
*a few drops of copper chloride in the channel until the solution meets the electrodes
▪Place the lid on the petri dish
▪Connect the power supply setting at 6 volts (DC)
▪Observe and explain the reactions at the electrodes, with the solutions and with the indicator paper.

See laminate below

EXPERIMENT 4: Microscale Electrolysis

This electrolysis uses carbon electrodes and a plastic channel to contain the electrolyte solution.

A lid on the Petri dish contains any harmful gases.



Wipe the petri dish clean between each experiment.

Set up a circuit using a 9-volt battery / power supply and pegs to hold the carbon fibre electrode rods.

Place a Petri dish on the template.

Put 1 drop of KBr solution and 1 drop of KI solution in the circles as shown and place the indicator paper as indicated.

Insert the carbon electrodes into the plastic channel.

Add sufficient drops of copper chloride solution to cover the ends of both electrodes.

Place the lid on the Petri dish and turn on the power.

Observe and record your observations.

Other electrolysis experiments to try. Put the solution in the plastic channel.

- Potassium iodide with a drop starch solution.
- Silver nitrate solution.
- Sodium sulphate solution with a drop of UI solution.

https://science.cleapss.org.uk/Resource/PP059-Micro-electrolysis-of-copper-II-chloride-solution.pdf

https://science.cleapss.org.uk/Resource-Info/Microscale-Electrolysis-of-Copper-Chloride.aspx

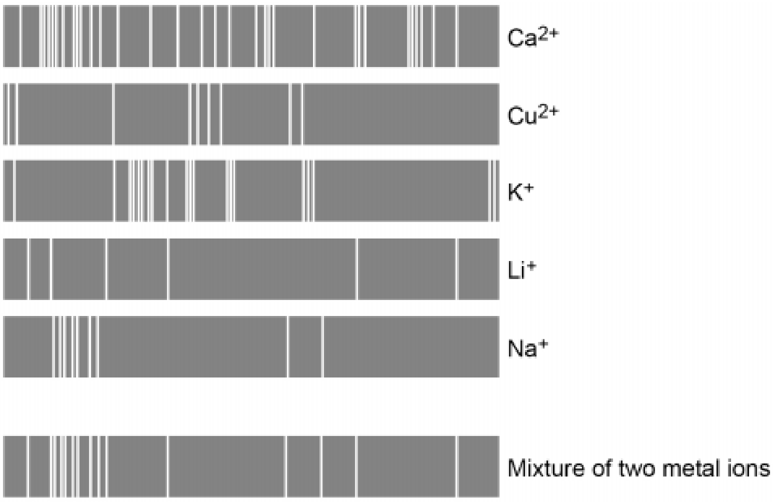
Examination questions

0 1 . 4 Flame emission spectroscopy is used to identify metal ions in a firework.

Figure 1 shows:

- the flame emission spectra of five individual metal ions
- a flame emission spectrum for a mixture of two metal ions.

Figure 1



Which **two** metal ions are in the mixture?

[2 marks]

Tick **two** boxes.

Ca^{2+} ☐

Cu^{2+} ☐

K^{+} ☐

Li^{+} ☐

Na^{+} ☐

The compounds in fireworks also contain non-metal ions.

A scientist tests a solution of the chemicals used in a firework.

0 1 . 5 Silver nitrate solution and dilute nitric acid are added to the solution.

A cream precipitate forms.

Which ion is shown to be present by the cream precipitate?

[1 mark]

____

0 1 . 6 Describe a test to show the presence of sulfate ions in the solution.

Give the result of the test if there are sulfate ions in the solution.

[3 marks]

Test ____

____

____

____

Result ____

____

Mark scheme

01.3	(flame) colours are masked	allow (flame) colours mix / blend allow only see one colour allow cannot see two colours at once ignore hard to distinguish	1	AO1 4.8.3.1
01.4	Li^+ Na^+		1 1	AO2 4.8.3.7
01.5	bromide (ion)	allow Br^- ignore bromine	1	AO1 4.8.3.4
01.6	add barium chloride (solution) add hydrochloric acid white precipitate produced	allow barium nitrate (solution) allow nitric acid allow acidified do **not** accept sulfuric acid dependent on use of a barium compound	1 1 1	AO1 4.8.3.5

Q2

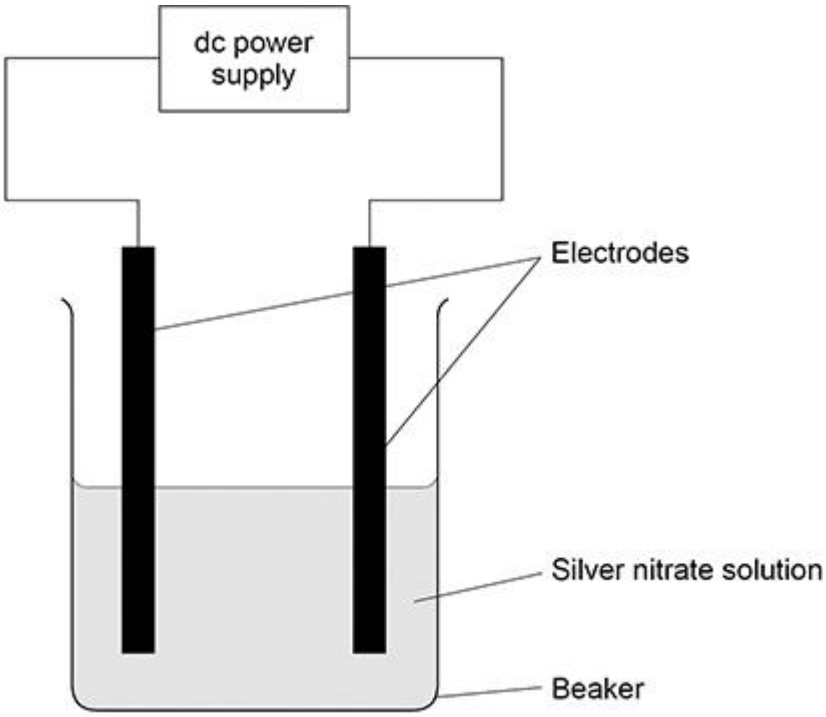
This question is about electrolysis.

Some students investigated the electrolysis of silver nitrate solution.

This electrolysis produces silver at the negative electrode.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Switch on the power supply.
4. Switch off the power supply after five minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

(a) Some silver did not stick to the negative electrode but fell to the bottom of the beaker.

The students needed to weigh this silver.

How could the students separate the silver from the silver nitrate solution?

Tick (✓) **one** box.

By chromatography ☐

By crystallisation ☐

By distillation ☐

By filtration ☐

(1)

Table 1 shows the students' results.

Table 1

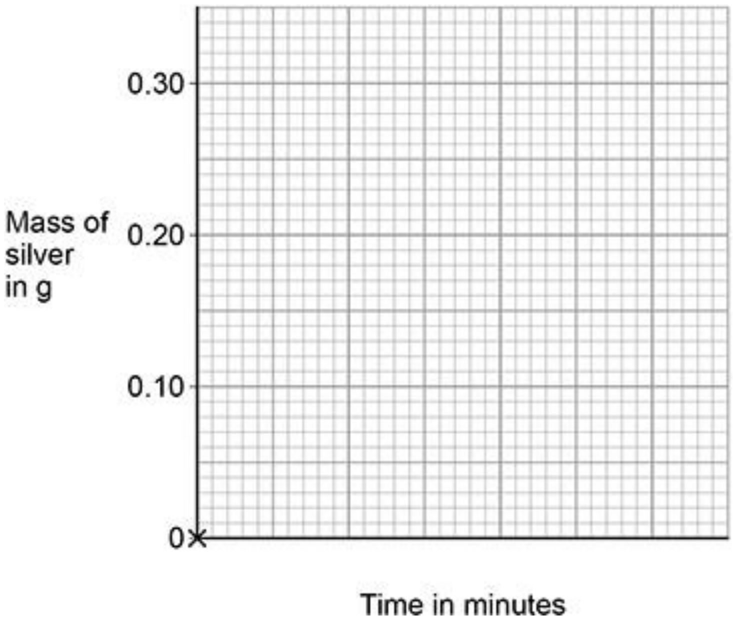
Time in minutes	Mass of silver in g
0	0.00
5	0.06
10	0.12
15	0.18
20	0.24
25	0.30

(b) Draw a graph on **Figure 2**.

You should:

- use a suitable scale for the x-axis
- plot the data from **Table 1**
- draw a line of best fit.

Figure 2



(4)

(c) Determine the mass of silver that would be produced after 12 minutes.

Use **Figure 2**.

(1)

(d) A student investigated the electrolysis of two aqueous salt solutions.

Hydrogen is produced at the negative electrode when the metal in the salt solution is more reactive than hydrogen.

Complete **Table 2** to show what the student would **observe** at the negative electrode for each salt solution.

Table 2

Salt solution	**Observation at negative electrode**
Copper sulfate	
Sodium chloride	

(2)

(e) A teacher demonstrates the electrolysis of molten lead bromide.

The products at the electrodes are lead and bromine.

Why should the teacher do the demonstration in a fume cupboard?

(1)

(f) Two other molten compounds are electrolysed.

Complete **Table 3** to show the molten compounds and the products.

Table 3

Molten compound electrolysed	Product at the negative electrode	Product at the positive electrode
Zinc chloride		
	Potassium	Iodine

(3)
(Total 12 marks)

Q3.

This question is about chemical reactions and electricity.

(a) Electrolysis and chemical cells both involve chemical reactions and electricity.

Explain the difference between the processes in electrolysis and in a chemical cell.

(2)

(b) A teacher demonstrates the electrolysis of molten lead bromide.

Bromine is produced at the positive electrode.

Complete the half equation for the production of bromine.

You should balance the half equation.

$$Br^- \rightarrow \quad\quad + $$

(2)

(c) Two aqueous salt solutions are electrolysed using inert electrodes.

Complete the table below to show the product at each electrode.

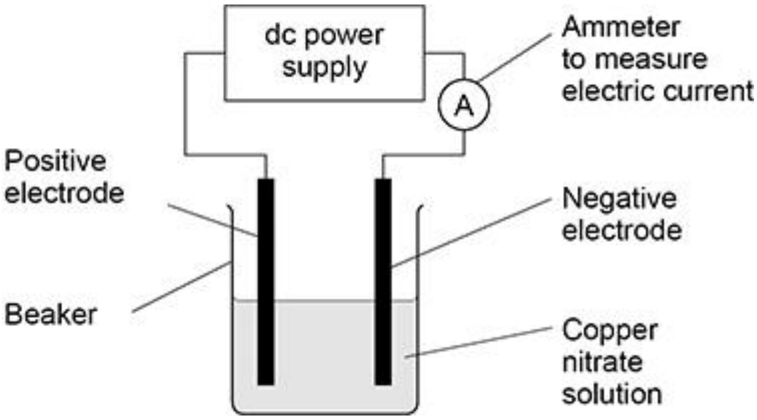
Salt solution	Product at positive electrode	Product at negative electrode
Copper nitrate		copper
Potassium iodide		

(3)

Some students investigated the electrolysis of copper nitrate solution using inert electrodes.

Figure 1 shows the apparatus.

Figure 1



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.
8. Repeat steps 1 to 7 at different currents.

(d) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

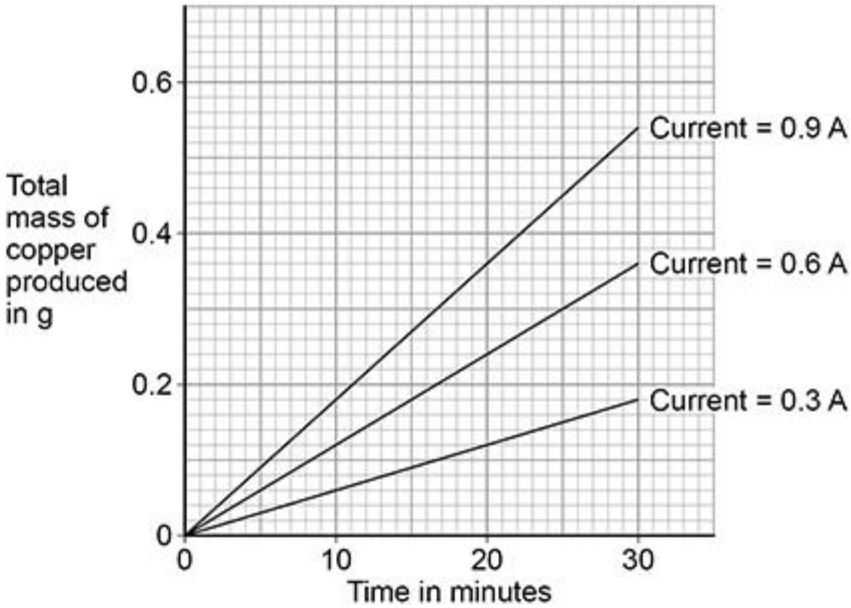
Suggest how the students could find the total mass of copper produced.

(4)

The students plotted their results on a graph.

Figure 2 shows the graph.

Figure 2



A student correctly concluded that the total mass of copper produced is directly proportional both to the time and to the current.

(e) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the time?

(1)

(f) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the current?

Use data from **Figure 2** in your answer.

(1)

(g) Copper nitrate solution is blue.

Suggest why the blue colour of the copper nitrate solution fades during the electrolysis.

(1)

(h) Determine the number of atoms of copper produced when copper nitrate solution is electrolysed for 20 minutes at a current of 0.6 A

Give your answer to 3 significant figures.

Use **Figure 2**.

Relative atomic mass (A_r): Cu = 63.5

The Avogadro constant = 6.02×10^{23} per mole

(3)

(Total 17 marks)

Q4.

Potash alum is a chemical compound.

The formula of potash alum is $KAl(SO_4)_2$

(a) Give a test to identify the Group 1 metal ion in potash alum.

You should include the result of the test.

(2)

(b) Name **one** instrumental method that could identify the Group 1 metal ion **and** show the concentration of the ion in a solution of potash alum.

(1)

A student identifies the other metal ion in potash alum.

The student tests a solution of potash alum by adding sodium hydroxide solution until a change is seen.

(c) Give the result of this test.

(1)

(d) This test gives the same result for several metal ions.

What additional step is needed so that the other metal ion in potash alum can be identified?

Give the result of this additional step.

(2)

(e) Describe a test to identify the presence of sulfate ions in a solution of potash alum.

Give the result of the test.

(3)

(Total 9 marks)

Q2.

(a) by filtration

1

(b) 10 minutes per 2 cm on x-axis

allow 5 minutes per 1 cm on x-axis

1

all points plotted correctly

allow a tolerance of ± ½ a small square

allow ***1*** *mark for 3 or 4 points plotted correctly*

2

line of best fit

allow line of best fit drawn using incorrect plots

1

(c) 0.14 (g)

allow ecf from question ***(b)***

allow a tolerance of ± ½ a small square

1

(d) (copper sulfate solution) pink / orange / red / brown solid

allow copper plating

allow metal for solid

1

(sodium chloride solution) bubbles / effervescence / fizzing

if no other mark awarded allow ***1*** *mark for copper* ***and*** *hydrogen*

1

(e) toxic / poisonous (fumes)

allow harmful / corrosive (fumes)

ignore dangerous / deadly / lethal

1

(f)

Molten compound electrolysed	**Product at the negative electrode**	**Product at the positive electrode**
(zinc chloride)	zinc (1)	chlorine (1)
potassium iodide	(potassium)	(iodine)

allow **1** mark if zinc and chlorine the wrong way round

2

1

[12]

Q3.

(a) electrolysis uses electricity to produce a chemical reaction

allow voltage for electricity

allow potential difference for electricity

allow (electrical) current for electricity

allow electrolysis uses electricity to decompose a compound / electrolyte

1

(but) cells use a chemical reaction to produce electricity

1

(b) $2Br^- \rightarrow Br_2 + 2e^-$

allow multiples

*allow **1** mark for Br_2 **and** e^-*

2

(c)

Salt solution	Product at positive electrode	Product at negative electrode
(copper nitrate)	oxygen (1)	(copper)
(potassium iodide)	iodine (1)	hydrogen (1)

1
2

(d) filter the mixture

1

wash and dry the copper / residue

1

weigh the copper collected

1

add to the increase in mass of the electrode

1

(e) (for given current) straight line through the origin

allow (for given current) when time doubles, mass doubles

1

(f) (for given time) when current doubles, mass doubles with supporting data

1

(g) copper ions are discharged (from the solution)

allow the solution becomes less concentrated

allow copper ions are removed (from the solution)

allow copper ions are used up (from the solution)

1

(h) (number of moles = $\frac{0.24}{63.5}$ =)

3.78×10^{-3} **or** 0.00378

1

(number of atoms =)
$0.00378 \times 6.02 \times 10^{23}$

allow correct use of an incorrectly calculated number of moles

1

$= 2.28 \times 10^{21}$

allow a correct evaluation to 3 significant figures of an incorrect expression which involves only a mass from the graph, the A_r of copper and the Avogadro constant

1

[17]

Q4.

(a) flame test

allow description of flame test

1

lilac (flame)

1

(b) flame emission spectroscopy

1

(c) white precipitate

ignore precipitate dissolves

1

(d) (add) excess sodium hydroxide (solution)

allow (add) more sodium hydroxide (solution)

1

precipitate dissolves

1

(e) add barium chloride (solution)

allow add barium nitrate (solution)

1

add (dilute) hydrochloric acid

allow add (dilute) nitric acid

1

white precipitate

dependent on MP1 being awarded

1

[9]

Examiner reports

Q3.

(a) Very few students picked up on the link between chemical reactions and electricity given in the question. The idea that electrolysis uses electricity to produce a chemical reaction was poorly understood. Many students believe electrolysis is a method of 'separating' compounds, rather than decomposing a compound. Very few realised that a chemical cell uses a reaction to produce electricity, with many making statements about a cell using electricity.

(b) Many students were unable to write the formula of bromine. Those who could, often scored at least one mark, although the half-equation was not always balanced.

(c) Students found difficulty in naming all 3 products. Many students did score the mark for iodine, though iodide was a common response. Very few could work out that in the absence of a halide ion, oxygen must be produced at the positive electrode, with many suggesting nitrogen as the product.

(d) Of the students who recognised that the copper needed to be filtered from the solution, very few then washed and dried the copper, despite that step having been provided in the method for dealing with the electrode itself. Some said the filtered copper would be measured, rather than specifically that the mass would be measured. Some then said incorrectly that the mass would be added to the mass of the electrode, rather than the mass gain of the electrode. Many wasted time describing steps that had already been done, particularly weighing the electrode before and after the experiment.

(e) The concept of proportionality is poorly understood. Even those who referred to the lines being straight rarely referred to their passing through the origin. Most simply described how the results showed a positive correlation, or a linear relationship.

(f) The idea of one variable doubling (or trebling) as did the other variable was known by very few students.

(g) Very few recognised that the blue colour was due to copper ions, which were being removed from the solution. Copper does not dissolve, and is not blue, so the phrase 'copper is removed from the solution' has no merit. Many think that the ions are being separated, rather than discharged.

(h) Many students could make no progress as they had not calculated the number of moles of copper. Some tried to include the current, the time or both in their calculation, instead of using those values to establish the mass of copper formed from the graph.

Q4.

(a) Over half of the students knew that a flame test should be used but fewer knew the correct result for potassium.

(b) Only a few students mentioned flame emission spectroscopy as an instrumental alternative to a flame test.

(c) Just over a third of students gave white precipitate.

(d) Very few students were able to complete the steps needed to differentiate between metal ions producing a white metal hydroxide precipitate.

(e) Students found this difficult with many students unable to go beyond the need to acidify the solution being tested.

Improving your subject knowledge

RSC

https://edu.rsc.org/cpd/laboratory-skills/2500137.article

Doc Brown

https://docbrown.info/page10/page10.htm#analysis